Autonomous Drone Navigation for Extended Cellular Reception During Disaster Relief Operations

Contributors:

Debbie Liske

Matthew Parker

Teena Thankachan

Sprint 2022 DGMD E-17 - Harvard Extension School - May 9, 2022

Introduction and Background

Team Organization

Data Science	Data Engineering	Simulation, Hardware, and Testing
Debbie	Teena	Matthew

Presentation Focus

Since the A4 homework and our final project are both drone related, we opted to focus on the Homework submission and then demonstrate some improvements to the autonomous drone operations via the use of deep learning computer vision algorithms

Therefore, this presentation is split into two sections:

- Demo of the A4 drone operations
- Process to expand and improve autonomous operations

HW A4 Drone Ops

Configuration

This homework expanded on the autonomous driving example by using some new tools and techniques.

PX4 Drone Simulator: Python interface for drone operations

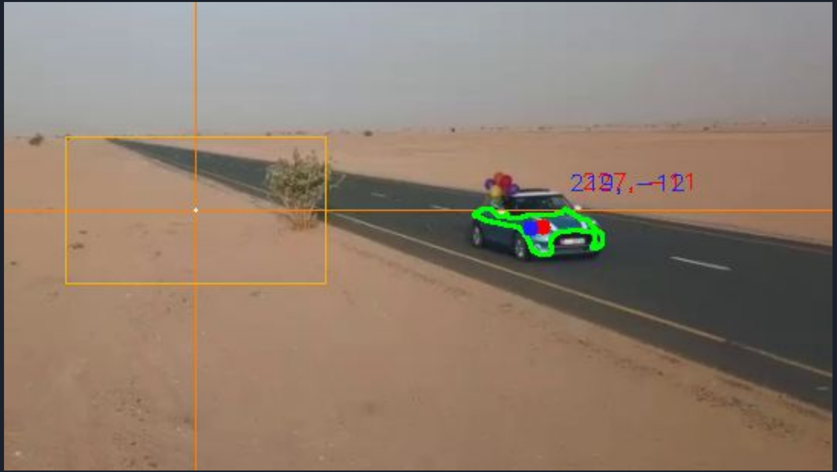
QGround Control: Flight control system

MavLink: Communication protocol

OpenCV Object Detection

Similar to the earlier homework for robot object tracking, an object detection system is required.

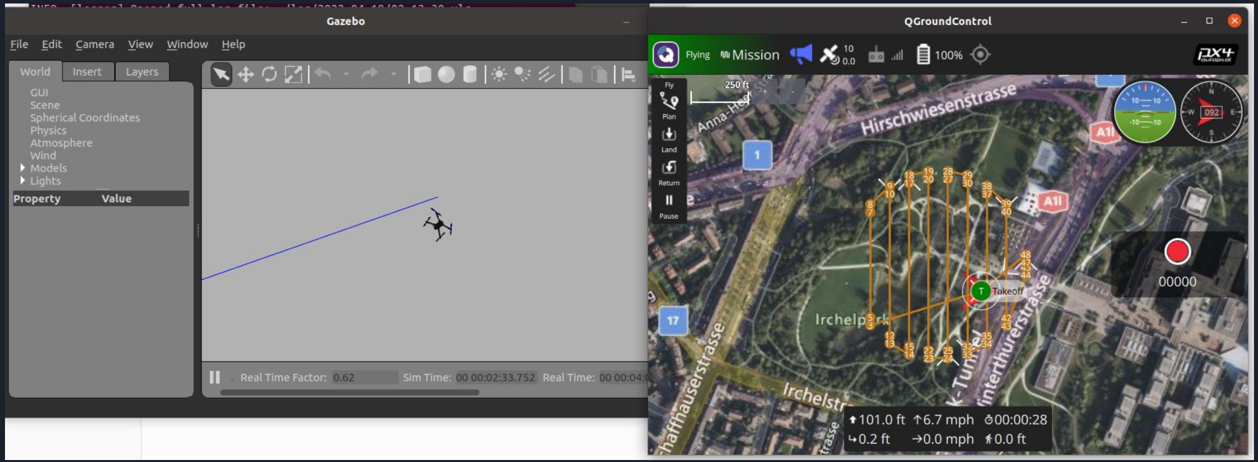
- Utilize camera
- Use basic RGB segmentation and isolate “blue” object
- Apply bounding box and find location of the center of the object within the image.



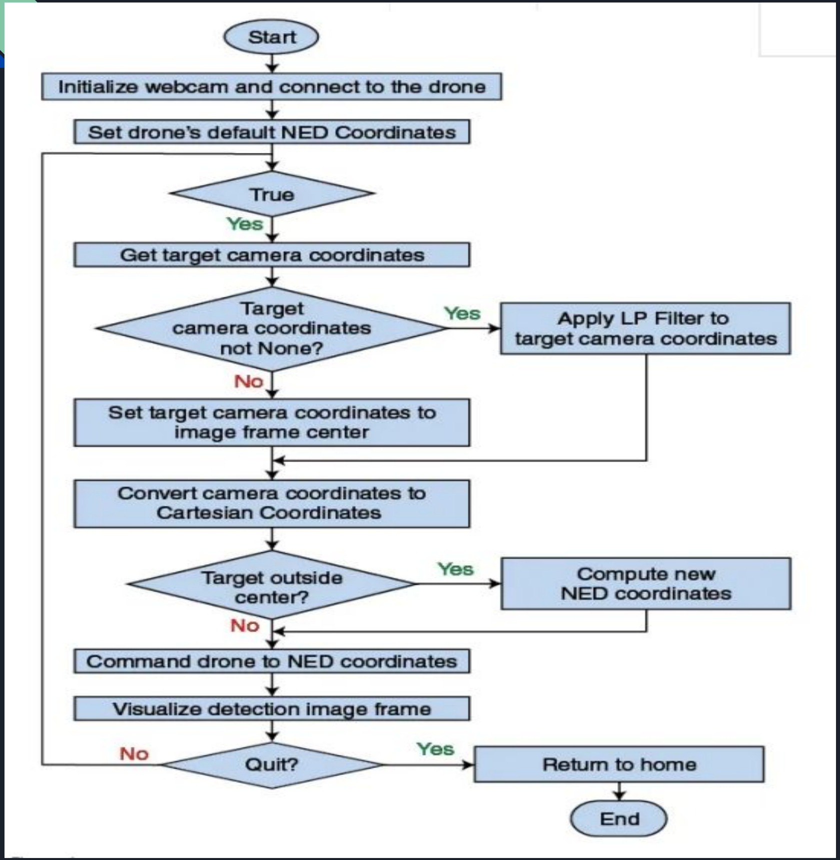
Initial Drone Flights

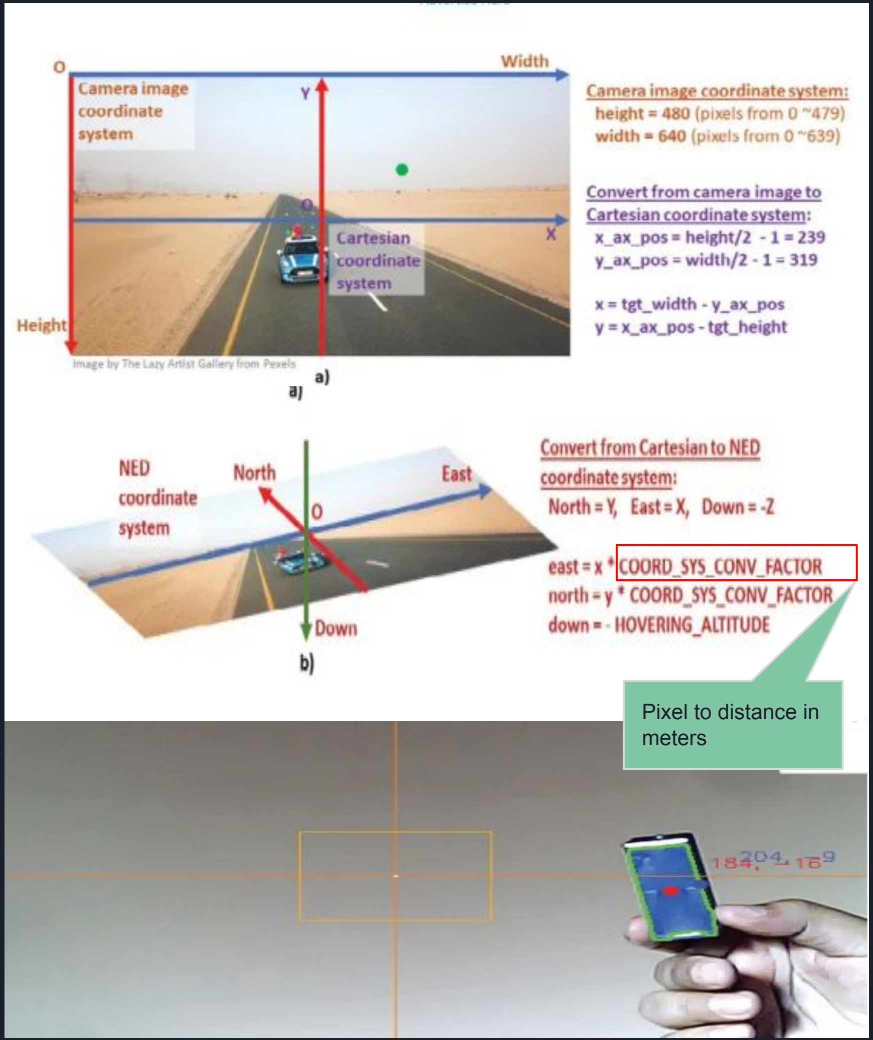
A model of an Iris drone is loaded into the Gazebo simulator into an empty world.

The QGround Control system interfaces with the PX4 simulator via the use of the MavLink comms protocols and sends commands to the drone.



Architecture

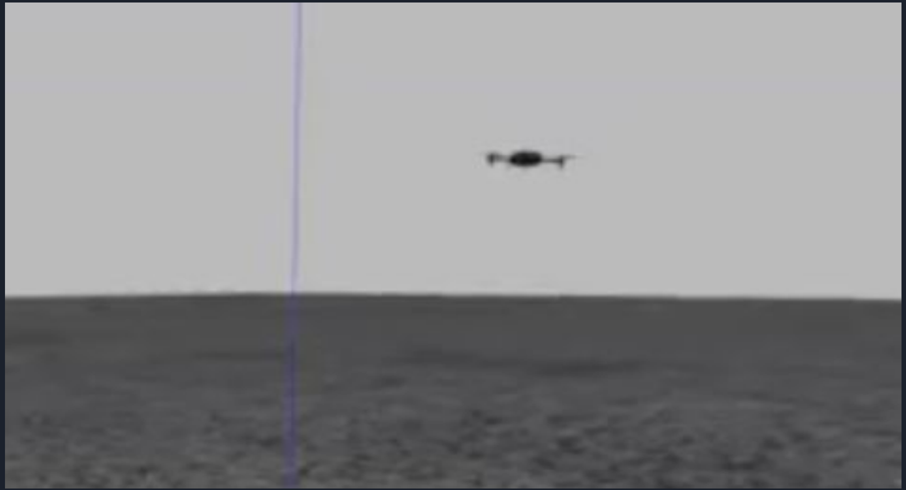


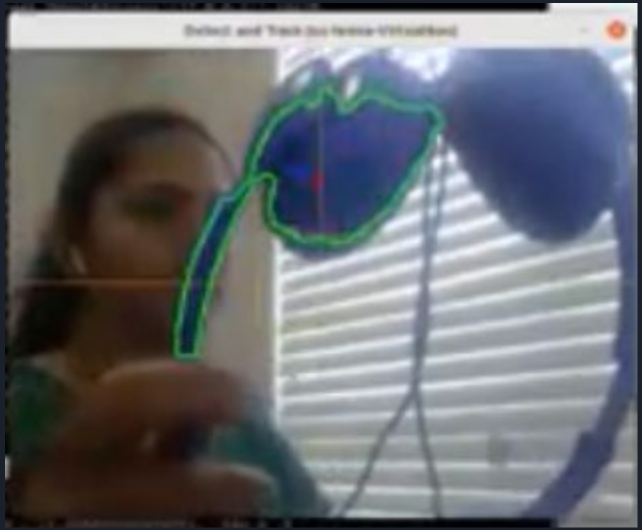


Extend to Drone Camera

To test the code example in simulation, take the following steps:

1. Use install_run_simmulation.md to install PX4 STIL,MAXSDK-python ,QGroundControl
2. Run the PX4 & Gazebo, or PX4 & JMAVSim simulator.
3. Open QGroundControl.
4. Execute track_and_follow.py script.





Demo Video

Final Project Drone Advancements

Motivations

Roughly 6,800 natural disasters take place every year, around the globe [1].

During those events, cellular communication services may be disrupted and people affected by the disaster may not have an ability to reach out for help.

This project aims to utilize a drone which would, in theory, contain a small mounted cell site that can fly autonomously to a disaster region where towers, or smaller cell sites have been damaged by storms. This would enable more coverage for first responders or those directly affected by the storm who are without (or with poor) cellular service.

Project Objectives

- Implement a real-time, deep learning Computer Vision algorithm utilizing an autonomous drone camera
- Navigate obstacles on a closed, indoor test track
- Land safely on a designated target

Project Details

More information is outlined in a separate XMind file which covers

- Project background
- Deep learning algorithm Design
- Collaboration efforts to create code
- Results

Demo Video

Challenges and Future Work

Challenges

1. Issues with ROS version incompatibility
    a. There are multiple generations of ROS software, each of which is not directly compatible with code syntax.
    b. This caused issues by attempting to extend a ROS program built in an earlier version for this project
2. The only drones capable of running deep learning code and ROS are expensive (>$1500 USD) which was not feasible for this course
    a. Therefore, focus was placed on simulation only

Future Development Objectives

1. Get drone system fully functional using software simulator to test and optimize computer vision algorithms
2. Deploy system to live drone hardware
   a. Want to test full CV system on a real drone on a real-world course
3. Optimize deep learning algorithm for more advanced navigation techniques in complex environments like natural disaster zones.

Thank you!

References

- [1]: Natural Disaster Statistics — The US and the World (2021), https://policyadvice.net/insurance/insights/natural-disaster-statistics/
- [2]: ROS 1 Documentation, https://wiki.ros.org/
- [3]: Gazebo Simulation Software system, http://gazebosim.org/
- [4]: DJI Drone hardware, https://www.dji.com/mini-se/specs
- [5]: Onboard SDK for ROS with DJI drone platforms, https://github.com/dji-sdk/Onboard-SDK-ROS
- [6]: DJI Mobile SDK now supports Mini 2, Mini SE, Air 2S drones, Jan 2022, https://dronedj.com/2022/01/03/dji-sdk-mini-2-se-air-2s/
- [7]: Tech Talk: Untangling The 5 Levels of Drone Autonomy, Mar 2019, https://droneii.com/drone-autonomy
- [8]: ROS.org tum_simulator: http://wiki.ros.org/tum_simulator
- [9]: https://drone.sjtu.edu.cn/contest/wp-content/uploads/2013/11/ROS_Gazebo_Quadrotor_simulator.pdf (to help understand the initial simulation piece, prior to CV).
- [10]:Deep Convolutional Neural Network-Based Autonomous Drone Navigation https://arxiv.org/pdf/1905.01657.pdf
- [11]: Deep Neural Network for Autonomous UAV Navigation in Indoor Corridor Environments https://www.sciencedirect.com/science/article/pii/S1877050918310524
- [12]: Programming drones with Raspberry Pi on board, easily, Nov 2020, https://www.hackster.io/korigod/programming-drones-with-raspberry-pi-on-board-easily-b2190e